DACA42-03-C-0024

LOGANEnergy Corp.

Campbell Hall Combined Services ROTC Building
North Carolina Agricultural and Technological State University
Greensboro, North Carolina
PEM Demonstration Program
Midterm Report

Exchange Membrane (PEM) Fuel Cell Demonstration
Of Domestically Produced PEM Fuel Cells in Military Facilities

US Army Corps of Engineers
Engineer Research and Development Center
Construction Engineering Research Laboratory
Broad Agency Announcement CERL-BAA-FY02

North Carolina Agricultural and Technological State University,
Greensboro, North Carolina

May 14, 2004

Executive Summary

LOGANEnergy Corporation has received a contract award from the US Army Corps of Engineers, Construction Engineering Research Lab to test and evaluate Proton Exchange Membrane (PEM) Fuel Cells at several DOD sites. The North Carolina A&T State University, Greensboro, NC was one of the sites awarded to LOGAN. This PEM demonstration site is now operational after the initial start-up occurred on April 23, 2003.

The Campbell ROTC Building was chosen for the demonstration site. It hosts a 5kW, 120vac, SU-1 PEM technology demonstration unit manufactured by Plug Power Corporation, Latham, NY. The unit will operate in a grid parallel / grid synchronized configuration at 2.5kW for the one-year demonstration test program. The unit is instrumented with an external wattmeter and a gas flow meter. A phone line is connected to the power plant communication's modem to call-out with alarms or events requiring service and attention.

The Point of Contact for this project is Dr. Harmohindar Singh, Director of the Energy Research Center, (336) 334-7575.
The total estimated energy cost increase to the host site as a result in participating in this demonstration project is -$585.08.

Table of Contents

Proposal – Proton Exchange Membrane (PEM) Fuel Cell Demonstration of Domestically Produced Residential PEM Fuel Cells in Military Facilities

1.0 Descriptive Title

Campbell Hall Combined Services ROTC Building PEM Demonstration Program, North Carolina Agricultural and Technological State University, Greensboro, North Carolina

2.0 Name, Address and Related Company Information

LOGANEnergy Corporation

1080 Holcomb Bridge Road
BLDG 100- 175
Roswell, GA 30076
(770) 650- 6388

DUNS 01-562-6211
CAGE Code 09QC3
TIN 58-2292769

LOGANEnergy Corporation is a private Fuel Cell Energy Services company founded in 1994. LOGAN specializes in planning, developing, and maintaining fuel cell projects. In addition, the company works closely with manufacturers to implement their product commercialization strategies. Over the past decade, LOGAN has analyzed hundreds of fuel cell applications. The company has acquired technical skills and expertise by designing, installing and operating over 30 commercial and small-scale fuel cell projects totaling over 7 megawatts of power. These services have been provided to the Department of Defense, fuel cell manufacturers, utilities, and other commercial customers. Presently, LOGAN supports 30 PAFC and PEM fuel cell projects at 21 locations in 12 states, and has agreements to install 22 new projects in the US and the UK over the next 18 months.

3.0 Production Capability of the Manufacturer

Plug Power manufactures a line of PEM fuel cell products at its production facility in Latham, NY. The facility produces three lines of PEM products including the 5kW GenSys5C natural gas unit, the GenSys5P LP Gas unit, and the GenCor 5kW standby power system. The current facility has the capability of manufacturing 10,000 units annually. Plug will support this project by providing remote monitoring, telephonic field support, overnight parts supply, and customer support. These services are intended to enhance the reliability and performance of the unit and achieve the highest possible customer satisfaction. Scott Wilshire is the Plug Power point of contact for this project. His phone number is 518.782.7700 ex1338, and his email address is scott_wilshire@plugpower.com.

4.0 Principal Investigator(s)

Name	Samuel Logan, Jr.	Keith Spitznagel
Title	President	Vice President Market Engagement
Company	Logan Energy Corp.	Logan Energy Corp.
Phone	770.650.6388 x 101	860.210.8050
Fax	770.650.7317	770.650.7317
Email	samlogan@loganenergy.com	kspitznagel@loganenergy.com

5.0 Authorized Negotiator(s)

Name	Samuel Logan, Jr.	Keith Spitznagel
Title	President	Vice President Market Engagement
Company	Logan Energy Corp.	Logan Energy Corp.
Phone	770.650.6388 x 101	860.210.8050
Fax	770.650.7317	770.650.7317
Email	samlogan@loganenergy.com	kspitznagel@loganenergy.com

6.0 Past Relevant Performance Information

a) Contract: PC25 Fuel Cell Service and Maintenance Contract #X1237022

Merck & Company
Ms. Stephanie Chapman
Merck & Company
Bldg 53 Northside
Linden Ave. Gate
Linden, NJ 07036
(732) 594-1686

Contract: Four-year PC25 PM Services Maintenance Agreement.
In November 2002 Merck & Company issued a four-year contract to LOGAN to provide fuel cell service, maintenance and operational support for one PC25C fuel cell installed at their Rahway, NJ plant. During the contract period the power plant has operated at 94% availability. LOGAN performs the quarterly and annual service prescribed by the UTC, and performs other maintenance as required. The periods of unavailability are chiefly due to persistent inverter problems that seem to be endemic to the Toshiba power conditioning balance of the system. Field modifications and operating adjustments have largely cured the problem. Quarterly service events take 10 hours to complete with the unit under load, and the annual event takes approximately 35 hours with the unit shut down.

b) Contract: Plug Power Service and Maintenance Agreement to support one 5kWe GenSys 5C and one 5kWe GenSys 5P PEM power plant at NAS Patuxant River, MD.

Plug Power
Mr. Scott Wilshire.
968 Albany Shaker Rd.
Latham, NY 12110
(518) 782-7700 ex 1338

LOGAN performed the start-up of both units after Southern Maryland Electric Cooperative completed most of the installation work. The units are located at residential sites at Patuxant River Naval Air Station, VA and operate in standard gird connected/grid independent configurations. Both operate at 4.5kWe and have maintained 98% availability. The units, S/Ns 241 and 242 are two of the very latest GenSys models to reach the field. S/N 242 is Plug Power's first LPG fueled system to go into the field. Both have set a new level of performance expectations for this product, and are indicative of the success of the various test and evaluation programs that have been conducted over the past two years.

c) Contract: A Partners LLC Commercial Fuel Cell Project Design, Installation and 5-year service and maintenance agreement.

Mr. Ron Allison
A Partners LLC
1171 Fulton Mall
Fresno, CA 93721
(559) 233-3262

On April 20, 2004 LOGAN completed the installation of a 600kWe PC25C CHP fuel cell installation in Fresno, CA. The system operating configurations allow for both grid parallel and grid independent energy service. The grid independent system is integrated with a multi unit load sharing electronics package and static switch, which initial development was funded by ERDC CERL in 1999. This is the third fuel cell installation that uses the MULS System. The thermal recovery package installed in the project includes a 100-ton chiller that captures 210 degree F thermal energy supplied by the three fuel cells to cool the first three floors of the host facility. The fuel cells also provide low-grade waste heat at 140 degrees F that furnishes thermal energy to 98 water source heat pumps located throughout the 12-story building during the winter months.

7.0 Host Facility Information

Since its inception as a land grant university in 1891, North Carolina Agricultural and Technical State University is a public and comprehensive university committed to fulfilling its fundamental purposes through exemplary undergraduate and graduate instruction, scholarly and creative research, and effective public service. The university offers degree programs at the baccalaureate, master's and doctoral levels with emphasis on engineering, science, technology, literature and other academic areas.

As one of North Carolina's three engineering colleges, the university offers Ph.D. programs in engineering. Basic and applied research is conducted by faculty in university centers of excellence, in inter institutional relationships, and through significant involvement with several public and private agencies. The university also conducts major research through engineering, transportation, and its extension programs in agriculture.

The Army Reserve Officers' Training Corps program at A&T is made up of a broad cross-section of college students. That's because A&T hosts Army ROTC for all colleges and universities in the greater Greensboro area. This includes, Bennet College, Guilford College, Greensboro College, and the University of North Carolina at Greensboro. Elon College is an extension center of the NCA&T Army ROTC program. Reserve Officers' Training Corps is an elective course. Its subjects include principles of management, leadership development, national defense and military history.

Duke Power provides the university’s electricity, and Piedmont Natural Gas is the fuel provider.

8.0 Fuel Cell Installation

In December 2002, the Campbell Hall Combined Services ROTC Building at North Carolina Agricultural and Technological State University site was awarded to LOGAN, and the installation began in late February 2002. Figure 1 and Figure 2 are photos of the fuel cell on its pad at the Campbell Hall ROTC building.

The site provides a significant opportunity for the program, as it places an operating PEM fuel cell on a major southern university operating on a commercial grid system owned by Duke Power. The installation site occupies a very visible presence in a green space between the ROTC building and a student cafeteria. Piedmont Natural Gas installed a 300-foot natural gas line.

Figure 1

In Figure 2, at right, another view of the installation, shows the fuel cell against a backdrop of the Marshall ROTC Building. The fuel cell was rigged onto the pad with the assistance of a commercial fork truck. The mechanical room is conveniently located behind the adjacent brick wall. The photo also shows the natural gas meter at left and the electrical interface at right.

Figure 2

LOGAN contacted the North Carolina Department of Health and Natural Resources to inquire of the need to apply for an air quality permit to operate the fuel cell. Since the unit's emissions are less than 5 tons per year it qualified for the small generator exemption under in accordance with NC Code 2Q.0102Cq (e).

In addition LOGAN met with representatives of Duke Power to determine whether they would require any special safety equipment or other safety testing prior to beginning operations with the fuel cell. After a review of the fuel cell system, and in consideration of its very minor impact on the campus electrical distribution system, Duke had no objections to the installation plan.

The installation tasks were completed and the initial start of the NC A&T unit was on April 23, 2003, requiring a total of 155 man-hours to complete installation and commissioning.

NC A&T Installation Line Diagram

Campbell Hall ROTC Center

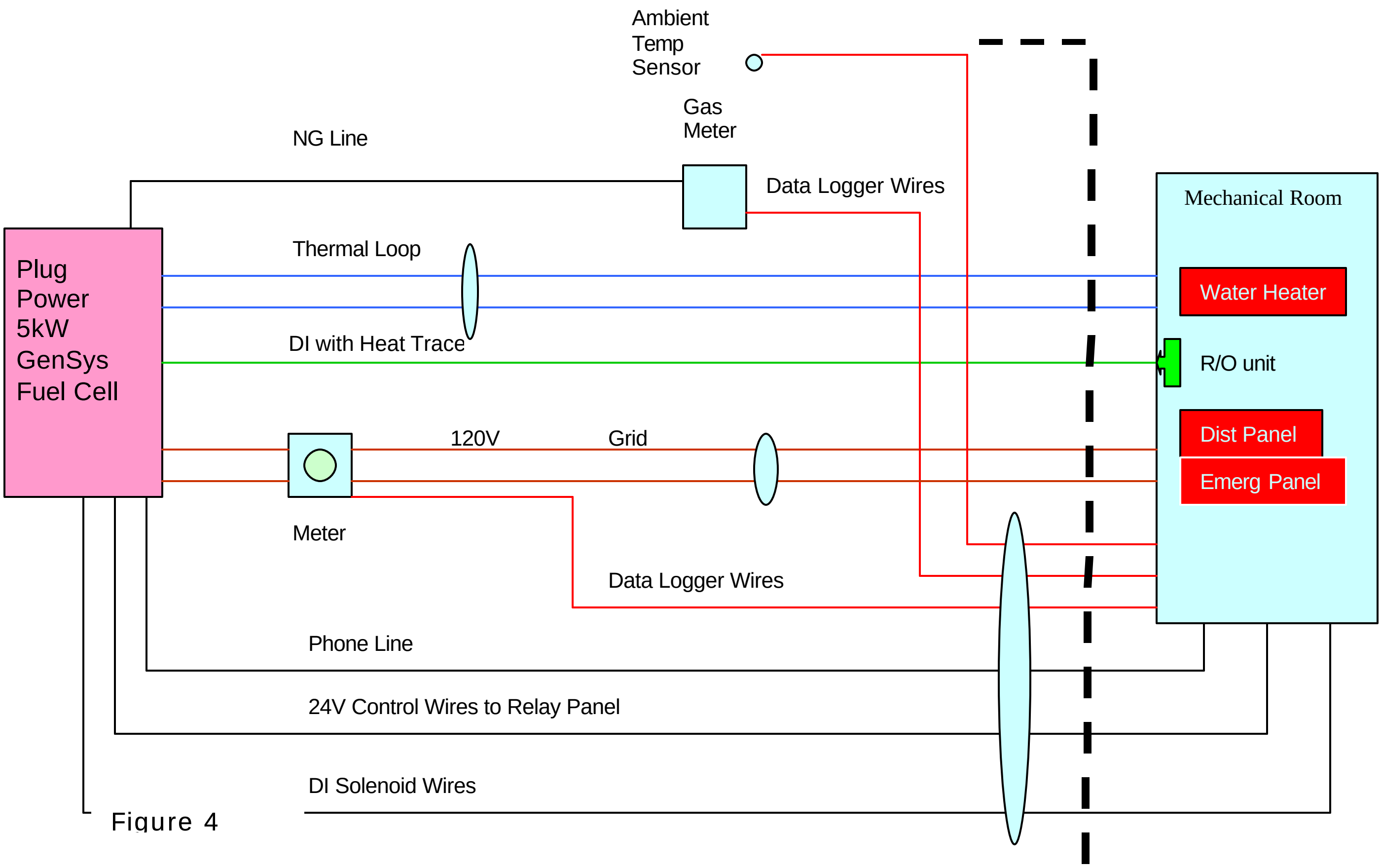

Figure 4

Figure 4, above, diagrams the fuel cell installation with utility interfaces including, power and water in the adjacent mechanical room of Campbell Hall.

9.0 Electrical System

The fuel cell inverter has a power output of 110/120 VAC at 60 Hz, matching the building distribution panel in the mechanical room with its connected loads at 110/120 VAC. The unit has the MP5 inverter that powers both grid parallel and a grid independent operating configuration as indicated in Figure 4. The unit provides stand-by power to a new 100amp critical circuit panel that serves plug loads throughout the facility. A two-pole wattmeter monitors both the grid parallel and grid independent lines to record fuel cell power delivered to both the existing panel and the new critical load panel installed in the building. Figure 2 shows the location of the electrical interface. The electrical conduit runs to facility load panels from the fuel cell are approximately 100 feet.

10.0 Thermal Recovery System

Figure 3, below, is a photo of the equipment and instrumentation installed to support the thermal recovery plan.

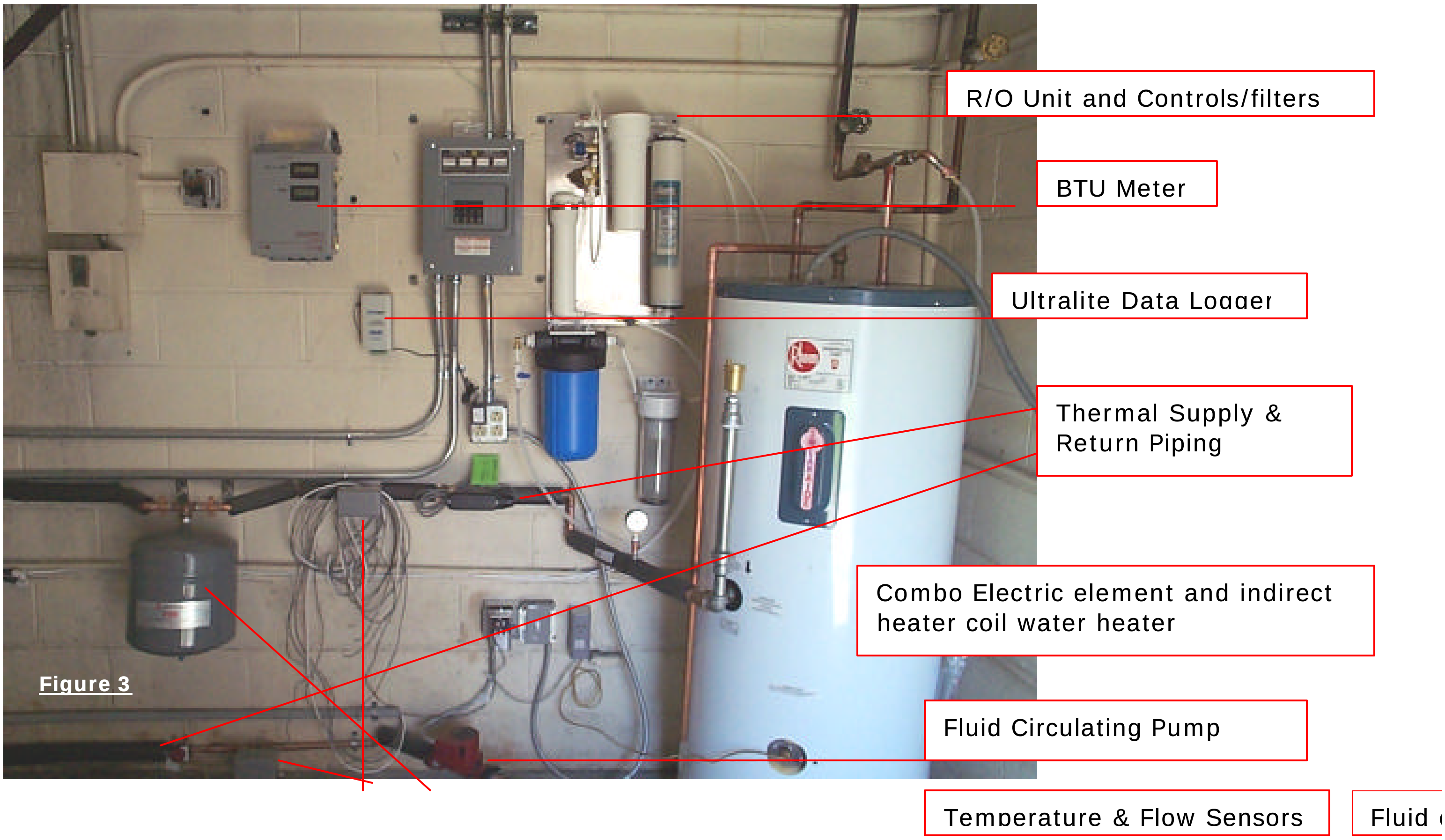

Figure 3

The thermal recovery system is designed to try to optimize the installation benefits to the host by capturing waste heat from the fuel cell and transferring it the building's thermal loads. The GenSys5C fuel cell incorporates a customer heat exchanger that rejects process heat to either an air-cooled radiator or to a waste heat loop. While operating at a set point of 2.5 kWh, the fuel cell provides 7800 Btuh to the storage tank at approximately 140 degrees F. The current design being tested at NC A&T represents both a design and cost improvement over LOGAN's first CHP installation at Ft. Jackson, SC. In this case, the waste heat circulates between the fuel cell and a new hot water tank installed by LOGAN that is a combination electric/indirect heat coil unit manufactured by Rheem. It replaces a old discarded electric hot water heater. Figure 4 is a photo of the thermal recovery components including the location of an Onicon BTU meter, circulating pump and the hot water storage tank. The small pump, pictured above, circulates a glycol solution between the fuel cell and the hot water tank transferring the fuel cell's waste heat into the tank as it flows through the coils wrapped circumferentially around the tank. However, the

The BTU meter provides a continuous output of heat transferred into the thermal recovery system.

11.0 Data Acquisition System

During the period October 2002 to August 2003, LOGAN's field service technicians performed their tasks with the support of a very rudimentary SCADA system developed by Plug Power for communicating with deployed units. This system provided one-way communication from each unit to Plug's customer support center, allowing the unit to call in overnight to download a data package and an operating status report. However, LOGAN realized very quickly that the system was inadequate and unreliable to provide the high level of communications support needed for its wide-ranging PEM demonstration program. At times a unit called in and provided only partial data or incorrect data. This created uncertainty in troubleshooting and further delay in restoring units to service. On other occasions a unit might fail to call in for a week or more frustrating the normal chain of events leading to a service advisory. While much can be said about the early learning curve experience in developing service norms, the weakness of the SCADA system became a major source of dissatisfaction with Plug Power. Under the circumstances the only means of determining a unit's actual status was to make a service call to the site. However, the scope of LOGAN's PEM program required a better solution. Finally, in March 2003 an event occurred that gave Plug direct insight into the shortcomings of its SCADA system. After advising of a shutdown at Ft Bragg, Plug sent its own technician to the site because LOGAN's technicians were servicing other units. The technician flew from Albany, NY to Raleigh, NC and then drove out to the site. Upon arriving, the technician discovered that the unit was operating normally. Indeed the SCADA system was not.

This event was an important turning point for the LOGAN/Plug Power relationship and its cooperative efforts in achieving the goals of the PEM Demonstration Program. Six weeks later in early June, six representatives from LOGAN and eight from Plug Power met in Atlanta for two days of forthright discussions. The meeting focused on short-term methods and longer term solutions to improve remote PEM fuel cell performance. Most significantly Plug determined that it would institute immediate software changes and upgrades to insure the accuracy of fuel cell data communications. Plug also promised to initiate a design change to its SCADA system that would permit bi-directional remote communications with the fuel cell controller. More importantly Plug promised that LOGAN's technicians would be able to remotely troubleshoot, change set points and attempt restarts under some circumstances. Lastly they also promised that they would publish a daily status report covering all of LOGAN's units. By early August Plug began sending daily status reports, and by mid September Plug shipped LOGAN's technician's new control software that permits remote diagnostics, monitoring, troubleshooting, and restart capabilities. Since the introduction of this new service capability along with the adoption of improved service techniques to go with it, fleet performance, availability and operating costs have begun to show positive new trends.

An Ultralite Logger pictured above in Figure 3 records and stores inputs from the wattmeter, gas meter, Btu meter and an ambient temperature probe. A phone connection to the unit permits remote data retrieval.

12.0 Fuel Supply System

Since natural gas was not immediately available to Campbell Hall, Piedmont Natural Gas of North Carolina provided matching funds of $10,500 to run a natural gas supply line approximately 300 feet to supply the fuel cell. After Piedmont stubbed the natural gas supply at the fuel cell pad, LOGAN installed a gas meter adjacent to the fuel cell pad as indicated in Figure 4 and seen in Figures 1 and 2. A regulator at the fuel cell gas inlet maintains the correct operating pressure at 10-14 inches water column.

13.0 Installation Costs

North Carolina Agricultural and Technological State University

Project Utility Rates					
1) Water (per 1,000 gallons)	$2.07				
2) Utility (per KWH)	$0.0350				
3) Natural Gas (per MCF)	$6.03				
First Cost				**Estimated**	**Actual**
Plug Power 5 kW GenSys5C				$ 65,000.00	$ 65,000.00
Shipping				$ 1,800.00	$ 425.00
Installation electrical				$ 4,200.00	$ 4,400.00
Installation mechanical & thermal				$ 6,400.00	$ 6,710.00
Watt Meter, Instrumentation, Web Package				$ 3,150.00	$ 4,454.00
Site Prep, labor materials				$ 925.00	$ 925.00
Technical Supervision/Start-up				$ 8,500.00	$ 13,950.00
Total				**$ 89,975.00**	**$ 95,864.00**
Assume Five Year Simple Payback				$ 17,995.00	$ 19,172.80
Forcast Operating Expenses	Volume		$/Hr	$/ Yr	
Natural Gas Mcf/ hr @ 2.5kW	0.0328	$	0.20	$ 1,561.14	
Water Gallons per Year	14,016			$ 29.01	
Total Annual Operating Cost					$ 1,590.15
Economic Summary					
Forcast Annual kWH			19710		
Annual Cost of Operating Power Plant		$	0.081	kWH	
Credit Annual Thermal Recovery		$	(0.016)	kWH	
Project Net Operating Cost		$	0.065	kWH	
Displaced Utility cost		$	0.035	kWH	
Energy Savings (Increase)			($0.030)	kWH	
Annual Energy Savings (Increase)			($585.08)		

Explanation of Calculations:

Actual First Cost Total is a *sum* of all the listed first cost components.
Assumed Five Year Simple Payback is the Estimated First Cost Total *divided by* 5 years.
Forecast Operating Expenses:

Natural gas usage in a fuel cell system set at 2.5 kW will consume 0.033 Mcf per hour. The cost per hour is 0.033 Mcf per hour *x* the cost of natural gas to NCA&T per Mcf at $6.03. The cost per year at $1561.14 is the cost per hour at $0.20 *x* 8760 hours per year *x* 0.9. The 0.9 is for 90% availability.

Natural gas fuel cell systems set at 2.5 kW will consume 1.6 gallons of water per hour through the DI panel. The total volume of water consumed at 14,016 gallons per year is 1.6 gph *x* 8760 hours per year. The cost per year at $29.01 is 14,016 gph *x* cost of water to NCA&T at $2.07 per 1000 gallons.

The Total Annual Operating Cost, $1590.15 is the *sum of* the cost per year for the natural gas and the cost per year for the water consumption.

Economic Summary:

The Forecast Annual kWh at 19,710 kWh is the product of 2.5 kW set point for the fuel cell system *x* 8760 hours per year *x* 0.9. The 0.9 is for 90% availability.

The Annual Cost of Operating the Power Plant at $0.081 per kWH is the Total Annual Operating Cost at $1590.15 *divided by* the forecast annual kWh at 19,710 kWh.

The Credit for Annual Thermal Recovery of $0.018/kWH equals 7800 BTU per hour thermal recovery at 2.5 kW *divided* by 3414BTU/kwH *multiplied* .20 recovery factor, *multiplied* by $0.0350/kWh. As a credit to the cost summary, the value is expressed as a negative number.

The Project Net Operating Cost is the *sum* of the Annual Cost of Operating the Power Plant *plus* the Credit Annual Thermal Recovery.

The Project Net Operating Cost is the *sum* of the Annual Cost of Operating the Power Plant *plus* the Credit Annual Thermal Recovery.

The Displaced Utility Cost is the kWh cost of electricity to the site.

Energy Savings (increase) equals the Displaced Utility Cost *minus* the Project Net Operating Cost.
Annual Energy Savings (increase) equals the Energy Savings *x* the Forecast Annual kWh.

14.0 Acceptance Test

An 8-hour acceptance test was run on April 28, 2003 by the technician. Please see Appendix 2 for documentation of the standard factory commissioning tasks and the acceptance test performed by the technician.

Appendix

1) Monthly Performance Data
2) Installation and Acceptance Test
3) Work Logs

1) Monthly Performance Data

Monthly Performance Data

North Carolina A&T

	May-03	Jun-03	Jul-03	Aug-03	Sep-03	Oct-03
Run Time (Hours)	565.99	1142.99	1833.99	2529.99	3044.49	3711.73
Time in Period (Hours)	744	1464	2208	2952	3672	4416
Availability (%)	76.1%	78.1%	83.1%	85.7%	82.9%	84.1%
Energy Produced (kWe-hrs AC)	1,347.4	2,777.4	4,503.3	6,253.7	7,523.7	9,174.7
Output Setting (kW)	2.50	2.50	2.50	2.50	2.50	2.50
Average Output (kW)	2.38	2.43	2.46	2.47	2.47	2.47
Capacity Factor (%)	36.2%	37.9%	40.8%	42.4%	41.0%	41.6%
Fuel Usage, HHV (BTUs)	18,759,889	39,383,891	63,935,012	89,413,948	107,907,005	132,080,562
Fuel Usage (SCF)	18,546	38,935	63,206	88,395	106,677	130,575
Electrical Efficiency (%)	24.5%	24.1%	24.0%	23.9%	23.8%	23.7%
Thermal Heat Recovery (BTUs)	258131	287800	496700	317425	234648	0
Heat Recovery Rate (BTUs/hour)	340.56	498.79	717.37	340.56	340.56	0
Thermal Efficiency (%)	1.03%	1.28%	2.02%	0.93%	0.95%	0
Overall Efficiency (%)	25.5%	25.4%	26.1%	24.8%	24.8%	23.7%
Number of Scheduled Outages	0	0	0	0	0	1
Scheduled Outage Hours	0	0	0	0	0	5
Number of Unscheduled Outages	1	3	3	4	5	6
Unscheduled Outage Hours	178	320	373	421	626	698

2) Installation and Acceptance Test

Site: North Carolina A&T Univ, Greensboro, NC...SU01-190

Installation Check List

TASK	Initials	DATE	TIME (hrs)
Batteries Installed	MH	3/24/03	2
Stack Installed	MH	3/24/03	3
Stack Coolant Installed	MH	3/26/03	1
Air Purged from Stack Coolant	MH	3/26/03	0.5
Radiator Coolant Installed	MH	3/26/03	2
Air Purged from Radiator Coolant	MH	3/26/03	1
J3 Cable Installed	MH	3/26/03	1
J3 Cable Wiring Tested	MH	3/26/03	0.5
Inverter Power Cable Installed	MH	3/26/03	0.5
Inverter Power Polarity Correct	MH	3/26/03	0.5
RS 232 /Modem Cable Installed	MH	3/26/03	0.5
Natural Gas Pipe Installed	MH	4/9/03	8
DI Water / Heat Trace Installed	MH	3/25/03	4
Drain Tubing Installed	MH	3/25/03	1

Commissioning Check List and Acceptance Test

TASK	Initials	DATE	TIME (hrs)
Controls Powered Up and Communication OK	MH	4/2/03	4
SARC Name Correct	MH	4/2/03	1
Start-Up Initiated	MH	4/22/03	6
Coolant Leak Checked	MH	4/22/03	1
Flammable Gas Leak Checked	MH	4/22/03	1
Data Logging to Central Computer	MH	4/22/03	1
System Run for 8 Hours with No Failures	MH	4/28/03	8

3) Daily work log for Mike Harvell, LOGANEnergy Field Technician
January 1, 2003 through July 31, 2003

Date	Activity	Hours
1/7/2003	Drove from Fayetteville to Greensboro for tomorrow's meeting.	2.5
1/8/03	Meeting with Dr. Singh, Alvin Howard, and Derrick Giles to look at proposed RFC location and discuss utility needs. Took pictures and found a good location. Drove back to Fayetteville.	6
1/15/03	Drove Logan, Binder, and Josefik to Greensboro from Sumter, SC.	5
1/16/03	Day was spent in meetings with CERL and NCA&T staff regarding installation requirements of the fuel cell.	6
2/24/2003	Put together a meeting with Dr. Singh & Co. Pulled together drawings and pictures to help the project manager understand the installation.	2
2/25/03	Drove to Greensboro and had a lengthy meeting with the project manager.	8
3/11/2003	Drove to A&T from Ft. Bragg. Watched school contractors finish RFC pad. Talked with David Lennon (school project manager) regarding how to get the fuel cell on the pad and when. Drove home.	7
3/17/03	Project planning and talking with David Lennon and contactors by phone.	2
3/19/03	Met with electricians and left some supplies at the site.	6.5
3/20/03	Planning and preparation.	3
3/23/03	Drove to Greensboro.	3.5
3/24/03	Installed stack, hot water heater, DPDT switch, base for electric meter, ran some pulse wires, hung DI panel, dug trench for conduit.	10
3/25/03	Electricians got power to the fuel cell (CL circuits have not been done yet). Plumbers cut sidewalk and ran conduit. I ran logger wires, phone line, DI wires, and CHP wires.	10
3/26/03	Connected batteries. Did voltage checks. Booted SARC. Flashed latest software version. Filled stack and system coolants. Plumbers repaired sidewalk, covered trench, hung Btu meter, started installing thermal loop components.	10
3/27/03	Worked on terminating control wires on the fuel cell end. Tried to get the inverter into mode 3 using Plug software, but had problems and will try again later. Plumbers completed thermal loop and filled it with glycol.	9
3/28/03	Commission DI panel, tried new USB adapter to get RFC into mode 3. Still no success. Plumbers completed their work by sealing hole in wall, wiring CHP relay and thermostat and making final connections to DI panel.	8.5
4/2/2003	Drove to Greensboro. Got the inverter into mode 3. Wired up the temp. and flow sensors on the Btu meter. Wired the 8 leads of the data logger	10.5

	to the Btu, electric, NG, and ambient sensors.	
4/3/03	Met with David Lennon to go over remaining issues that they need to do. Drove home.	4.5
4/9/03	Phone calls to Lennon and Shina. Faxed letter to Piedmont NG to have them place their NG meter.	1
4/21/03	Drove to Greensboro. Inspected the critical load circuits and noticed problems. Got David Lennon and we re-wired them all. Batteries were low, so I put the charger on overnight. Installed electric meter. DI wastewater drain is no good. Plumbers will fix.	11
4/22/03	Installed customer interface. Went for 2 starts but both ended in shutdowns. Believed to be the inverter.	9
4/23/03	PLUG found problem with inverter programming. It was easily remedied. Went for a start and all was well. Put decal on. Thermal loop was not working correctly. Put more glycol in (1/2-3/4 gallon). Still not working right. Took out Btu circuit boards to be shipped back and re-calibrated.	11
4/28/03	System shut down 24 hrs after initial start on low cell trip max. Installed new software and restarted. Appears to be running at a much better steam to carbon ratio.	9
4/29/03	Checked back with the fuel cell and all looked good. Programmed the data logger and got that working. Got the thermal loop working. Copied all screens at the different power levels. Drove back home.	8
5/2/2003	RFC supposedly shut down, but it was running when I arrived. Entered new setpoints and watched system for a while. Drove back.	8.5
5/7/03	Checked in. Took pictures. Checked DI system. VDC was 63.1.	5
5/27/03	Fuel cell had been down for about 7 days because of clogged filters. Had to change all 4 filters to get good flow. All had a reddish tint. Will send to Plug for testing.	10
6/10/2003	Downloaded data from data logger and fuel cell. Read meters. Tested conductivity. Did some troubleshooting to discover why data logger was not recording electric meter and remedied problem. Fuel cell looked good.	8
6/16/03	Fuel cell shut down on low DI tank. Filters were OK, but too much of the filtered water was going to the wastewater drain (starving the feedwater to the fuel cell). Took an Iron test and got 0.2 ppm.	7
6/17/03	Decided to change RO and carbon filter as a precaution. Did some thermal mapping.	5.5
6/26/03	Unit shut down yesterday on loss of inverter communication. Did some troubleshooting and found that the inverter needs replacing. Began installing new filtration system.	10.5

7/1/2003	Changed out inverter and tried 2 starts but they ended in shutdowns on low cathode inlet temp. Inverter change fixed the inverter problem. Low cathode inlet is a different problem.	7.5
7/2/03	Tried 3 more starts trying to get stack cells 2 & 3 to "dry out", but all ended in shutdowns. Pulled out the 3-way gas valve and checked solenoid. Checked 3-way cathode valve. Pulled stack out to check floats. Found no problems.	9.5
7/3/03	Installed new cell stack, restarted and drove home.	10.5
7/8/03	Fixed callout problem and drove home.	6
7/28/03	Gathered data, checked water filters, sent data to Dr. Singh. Drove home.	8

August-03

NC A&T

Date	PP S/N	Activity	Hours
8/11/03	SU190	Checked call-out data and system data. Made a few changes.	5.5
8/28/03		Checked out system and downloaded data. Looked good.	5.5

Sep-03

NC A&T

Date	PP S/N	Activity	Hours
9/9/03	190	Flashed new software. Re-installed inverter upgrade. Started system up.	13.5

Oct-03

NC A&T

Date	PP S/N	Activity	Hours
10/7/03	SN190	Drove to Greensboro, fuel cell was running, re-entered data logging parameters. Found bad thermal loop circulation pump.	5
10/14/03		Returned to A&T with new circulation pump, but found that the new pump would not circulate liquid just like the old one. Pumps were working, just not moving fluid. Will have to research possible design flaw.	10
10/21/03		Changed out desulfurizer and DI polisher and DI filters. Had many ATO and humidifier shutdowns.	10
10/22/03		Continued working on shutdown issues. Finally started for no apparent reason.	12.5